

I. EXECUTIVE SUMMARY

This Preliminary Engineering Report (PER) presents the results of a drainage study of "Kirkwood/ Briar Forest Storm Sewer Relief" C.I.P. No. M-126-37-2, File No. SM5002, contracted by United Engineers, Inc. (UEI) under City of Houston contract No. 051147. The study was commissioned by the City of Houston to identify problem drainage areas, recommend drainage improvements, and determine the impacts of improvements on abutting properties.

The study area is generally located in west Harris County within the city limits of the City of Houston, Council District "G" (See Vicinity Map, Exhibit 'A'). The area is generally bounded by Dairy Ashford Road to the west, Hayes Road to the east, Buffalo Bayou to the north, and Westheimer Road to the South.

The primary outfall for the project area is the Upper Buffalo Bayou watershed. The project overall drainage area is shown in Exhibit 'B'.

Information regarding the existing storm sewer system was gathered in the field and verified with record plans. This data was used to model the existing conditions. EPA Storm Water Management Model (SWMM) was used to simulate the existing conditions. The model was then updated to comply with established City of Houston criteria for storm sewers. All existing undersized inlets and lines were upgraded to City standard.

HEC-1 and HEC-2 models for Buffalo Bayou were obtained from the Harris County Flood Control District (HCFCD) and used to establish the existing 100-year event outflow. The proposed storm sewer that was designed based on the 2-year model was then subjected to the 100-year event to determine the additional capacity of the improvements and assess the total impact to the downstream properties.

While most of the improvements are located in public right-of-ways, some new or replacement storm sewer laterals will be located in existing easements.

The proposed storm sewer will be designed in accordance with City of Houston design guidelines and City of Houston specifications.

Approvals to construct the proposed storm sewer will be required from the City of Houston Department of Public works and Engineering, Southwestern Bell Telephone, Entex, H.L. & P., and the Harris County Flood Control District.

Based on the results of the study, United Engineers, Inc. recommends that the City of Houston implement the detailed recommendations provided in the PER in order to improve the drainage condition in the project area.

Further, we recommend that the City of Houston consider a regional detention pond in consultation with the Army Corp of Engineers and Harris County Flood Control District to mitigate impacts caused by storm sewer project improvements along Buffalo Bayou. The cost for mitigating the impact due to the improvements is approximately \$439,625.00. This cost does not include the land cost for the detention site.

The preliminary construction cost estimate for this project is \$8,474,325.00. A detailed cost estimate is provided in Tables 1 through 7.

II INTRODUCTION

A. Purpose and Scope

This Preliminary Engineering Report (PER) is being submitted in accordance with our contract No 051147 with the City of Houston, dated January 19, 2000 for the performance of a Professional Engineering Service. This report constitutes the preliminary phase of our agreement with the City.

The purpose and scope of this PER is to evaluate the present drainage conditions of the project area and to provide recommendations for improving the current drainage conditions.

The recommendations provided in this report, along with the City of Houston's general design requirements, standards, actual field investigations and studies, will be used when preparing the construction plans and specifications.

B. Authorization

This project was authorized by City of Houston Ordinance No 99-1197 and notice to proceed letter dated January 19, 2000. The ordinance authorized the performance of a preliminary engineering study to identify areas (within a given boundary) that experience drainage problems and to recommend solutions to alleviate the drainage problems.

C. Project Description and Study Background

1. Project Area Description:

The project area is generally located in west Harris County within the City of Houston City limits in Council District "G" (See Vicinity Map, Exhibit 'A'). The area is generally bounded by Dairy Ashford Road to the west, Hayes Road to the east, Buffalo Bayou to the north, and Westheimer Road to the South.

This project consists of six drainage sub-areas as shown in the overall area map (Exhibit 'B') that directly and/or indirectly outfall into Buffalo Bayou (W100). The sub-areas are identified by the system outfall identification numbers as designated by the Comprehensive Drainage Study conducted by Turner, Collie & Braden, Inc. (TC&B).

2. History of Flooding:

Residents in the area have experienced a history of flooding problems. The City of Houston (COH) Customer complaint database contains street flooding information throughout the project area.

3. Drainage systems:

The entire project area lies in the Buffalo Bayou (W100-00-00) watershed. This project consists of six drainage sub-systems. The following is a brief description of each drainage sub-area:

a. Drainage Sub-Area W0007:

The properties within this drainage area are fully developed as single-family homes. This sub-area lies within the Ashford Forest Subdivision (See Exhibit 'C'). This system drains approximately 11 acres and includes Carriage Hill Road, Shannon Valley Road and Shepherds Ridge Dr. This drainage sub area outfalls into Harris County Flood Control District (HCFCD) Ditch W165. Storm sewers in this sub-system are 24 inches in size.

b. Drainage Sub-Area W0008:

The properties within this drainage area are fully developed as single-family homes. This sub-area lies within the Heathwood Subdivision (See Exhibit 'D'). This system drains approximately 71 acres and includes Carriage Drake Mill Dr, Gladewick Dr, Crystal Hills Dr, and Heathwood Dr. This drainage sub area outfalls in HCFCD Ditch W165. Storm sewers in this sub-system range from 24 inches to 54 inches in size.

c. Drainage Sub-Area W0009:

The properties within this drainage area are fully developed as single-family homes. This sub-area lies within the Ashford Forest Subdivision (See Exhibit 'E'). This system drains approximately 26 acres and includes Carriage Hill Road, Shannon Valley, Deep Spring Lane and Berry wood Drive. This drainage sub area outfalls into HCFCD Ditch W165. Storm sewers in this sub-system range from 24 inches to 48 inches in size.

d. Drainage Sub-Area W0009A:

The properties within this drainage area are fully developed as single-family homes. This sub-area lies within the Ashford Forest Subdivision (See Exhibit 'F'). This system drains approximately 90 acres and includes Honeywood Trail, Ashford Parkway and Hazelwood Ln.

The Storm Sewer in this sub-area is fragmented. Several outfalls drain to an existing lake and existing ditches which ultimately drain into Buffalo Bayou.

e. Drainage Sub-Area W0010:

The properties within this drainage area are fully developed as single-family homes. This sub-area lies within the Ashford Hollow Subdivision (See Exhibit 'G'). This system drains approximately 54 acres and includes Briar Forest, Westmere Drive and Ashford Hollow Ln. This drainage sub area outfalls into HCFCD Ditch W165. Storm sewers in this system range from 24 inches to 60 inches in size.

f. Drainage Sub-Area W0014:

The properties within this drainage area are predominantly single-family homes with apartments located in the northeast and commercial properties located along southern portion of Kirkwood. This sub-area encompasses the Lakeside Place, Ashford Village, Southlake and Village West Subdivisions. The entire drainage area is considered fully developed. This system drains approximately 960 acres and includes storm sewer trunk lines along Kirkwood and Briar Forest.

The limit of this drainage area is Westheimer to the south, Hayes Road to the east, Buffalo Bayou to the north, and Gray Falls Dr and Drainage sub-area W0008 to the west. The system is the largest of the six drainage sub-areas and outfalls directly into Buffalo Bayou through a 14 foot CMP

4. Previous Drainage Studies:

The Comprehensive Drainage Study Plan initiated by TC&B was completed in September 1999. This study recommends some improvements to the existing storm sewer system. In the TC&B report, all the drainage sub-areas were shown to have adequate capacity to drain 2-year rainfall event except a few storm sewer pipes located in drainage sub-areas W0010 & W0014 as discussed below.

For drainage sub-area W0010, the study recommends that the present 21" RCP pipe along Briar Forest Drive between Ashford Parkway and HCFCD Ditch W165, be replaced by a 28" RCP.

For drainage sub-area W0014, the study recommends that the existing trunk sewer system along Kirkwood Road between Southlake Dr and Lakeside Place Dr, ranging in size from 84" to 132", be replaced by pipes ranging in size from 114" to 138".

5. Site Visits:

Site Visits of the project area were conducted to verify information obtained from various sources. Photographs were taken during these visits to document the existing inlet and outfall conditions for the major systems, as well as to document the general condition of the receiving ditches (See Appendix 'A').

6. Field Survey:

A field survey was conducted by the United Engineers, Inc. Survey Department and Western Group Consultants, Inc. The field survey tied all the existing drainage systems to a common datum (1973 adjustment). Spot elevations were taken at inlets and high points along streets. Flow lines of the existing storm sewers at the inlets, manholes and outfalls, when possible, were obtained, along with the pipe sizes and pipe lengths.

III METHODOLOGY

A. Design Criteria and General Approach:

The existing storm sewer system was designed using the pre-1996 City of Houston criteria. This criteria was based on a 3-year intensity co-efficient (CI) curve, which is also known as the **FUGET CURVE**. This curve was used in the Rational Method to Calculate run-off rates for each sub-catchment.

A runoff rate generated using the old City of Houston Criteria is substantially lower than the one generated using the current 2-year frequency.

The existing storm sewer system was evaluated using the current City of Houston design criteria as stated in the Design Manual for wastewater Collection Systems, Waterlines, Storm Drainage and Street Paving.

The current City of Houston design Guidelines require that all storm sewer systems be designed to handle the peak flow generated from a 2-year rainfall frequency. The peak runoff for each drainage area as calculated using the rational method.

The following specific criteria were used in this report: minimum velocity for Storm Sewer design is 3 feet per second (fps); minimum pipe size is 24-inch reinforced concrete pipe (RCP); minimum curb inlet size is type 'B-B' inlet.

When calculating the hydraulic gradient, the top of the outfall pipe is used as the starting water surface elevation. The hydraulic gradient shall at all times be below the gutter line.

Six Drainage sub-areas W0007, W0008, W0009, W0009A, W0010 and W0014 make up the entire project area in this study. A field survey was conducted to obtain the data from all the storm sewer lines, inlets, manholes and the Cross-Sections of the streets at low and high points. The existing HEC-1 and HEC-2 computer models for Buffalo Bayou (W100-00-00) were also obtained from HCFCD. These HEC models were used to generate the tailwater boundaries used in the 100-Year existing and proposed drainage models to analyze any relative impact on Buffalo Bayou from the proposed improvements in the W0014 drainage sub-area.

To analyze the hydrologic and hydraulic model for this project, we have used the Storm Water Management Modeling (SWMM) computer program as required by our contract.

B. Hydrologic Analysis:

The hydrologic analysis was performed using the Runoff Block from the SWMM model. The Runoff Block generates the hydrograph at each inlet, which is used to route through the storm sewer system in the EXTRAN Block of the SWMM model. To compute the hydrograph in the Runoff Block, the program requires Drainage Area, Time of Concentration, Percentage of Imperious, and Desired Year Rainfall Frequency.

C. Hydraulic Analysis:

Drainage areas W0007, W0008, W0009, W0009A, and W0010 are analyzed only for the 2-year event. Since W0014 directly outfalls into Buffalo Bayou, the area is analyzed for both 2-year and 100-year events. To analyze the storm sewer hydraulics the Extran block of Visual SWMM (graphical version EPA SWMM) model was used. Extran is a hydraulic flow routing model for the closed conduits in dendritic and looped networks. Extran receives hydrograph input at specific locations by interface file (from the Runoff block). The model performs dynamic routing of storm water flows throughout the major storm drainage system to outfall points of the receiving water system. Since the flow in sewers is usually non-uniform, turbulent, and subject to backwater and surcharge the Extran model is used to simulate all of the terms in the Dynamic Wave equation.

City of Houston design criteria require the downstream pipe crown as a boundary condition for all the 2-year conditions, therefore, the top of pipe elevation at the downstream end are used as boundary condition input to the Extran model. 2-year analysis was performed for a 6-hour simulation for all six drainage areas. The results are verified to identify any overflow above the gutter line. If there are overflow problems then solutions are proposed to fix them.

As it is mentioned above, W0014 was analyzed for both 2-year and 100-year events. Evaluation of the 100-year event is needed to determine any new impact to the downstream receiving system. To analyze the 100-year event, time-stage

relationship was used as the boundary condition. The time-stage relationship was developed from the HEC-1 and HEC-2 models for Buffalo Bayou for the W0014 outfall point. As per HCFCD requirements, the 100-year event is analyzed for 24 hours duration using the Extran model simulation.

IV EXISTING CONDITIONS

A. Existing Models:

The purpose of the existing model is to analyze the existing storm sewer and inlets and determine if these structures can adequately convey the current City of Houston 2-year rainfall event and comply with the City of Houston minimum design criteria for storm sewer systems.

The existing drainage systems are comprised of a network of curb inlets and storm sewers that collect runoff from streets. Sub-areas W0007, W0009 and W0010 generally have Type 'B' curb inlets (See photo No. 54), while Sub-areas W0008, W0009A, and W0014, the curb inlets are Type 'B-B'. The existing storm sewer pipes are shown on Exhibits 'C' through 'I'. In many areas, the existing storm sewer was not adequate to contain the 2-year rainfall event and the HGL was not kept below gutter.

The existing 2-year HGL worksheet (Appendix 'B') is the result of the study of the existing storm system, and shows all locations that have an inadequate storm sewer system.

Sub-area W0014 outfalls directly to Buffalo Bayou through a 168" pipe at Kirkwood Drive. To determine any additional impact due to improvement of storm sewer system in this area, the existing storm sewer was subjected to a 100-year rainfall event and the result will be compared with the proposed 100-year model. See Appendix 'D' for the detail of the existing 100-year model.

V PROPOSED CONDITIONS

The intent of the proposed drainage improvements is to bring the existing system into compliance with the current City of Houston criteria and improve the system's conveyance to relieve localized flooding in the project area.

A. Drainage Sub-Area W0007:

After replacing all existing substandard inlets and storm sewer lines in this system, a proposed 2-year design analysis was performed using SWMM. See Appendix 'C' for the final 2-year HGL worksheet.

The proposed storm sewers and inlets will contain the 2-year rainfall event within the pipes, keep the HGL below gutter line and bring this drainage system to current City of Houston standard. See exhibit 'C' for the drainage sub area map.

B. Drainage Sub-Area W0008:

After replacing all existing substandard inlets and storm sewer lines in this system, a proposed 2-year design analysis was performed using SWMM. See Appendix 'C' for final 2-year HGL worksheet.

The proposed storm sewers and inlets will contain the 2-year rainfall event within the pipes, keep the HGL below gutter line and bring this drainage system to current City of Houston standard. See exhibit 'D' for the drainage sub area map.

C. Drainage Sub-Area W0009:

After replacing all existing substandard inlets and storm sewer lines in this system, a proposed 2-year design analysis was performed using SWMM. See Appendix 'C' for final 2-year HGL worksheet.

The proposed storm sewers and inlets will contain the 2-year rainfall event within the pipes, keep the HGL below gutter line and bring this drainage system to current City of Houston standard. See exhibit 'E' for the drainage sub area map.

D. Drainage Sub-Area W0009A:

After replacing all existing substandard inlets and storm sewer lines in this system, a proposed 2-year design analysis was performed using SWMM. See Appendix 'C' for final 2-year HGL worksheet.

The proposed storm sewers and inlets will contain the 2-year rainfall event within the pipes, keep the HGL below gutter line and bring this drainage system to current City of Houston standard. See exhibit 'F' for the drainage sub area map.

E. Drainage Sub-Area W0010:

After replacing all existing substandard inlets and storm sewer lines in this system, a proposed 2-year design analysis was performed using SWMM. See Appendix 'C' for final 2-year HGL worksheet.

The proposed storm sewers and inlets will contain the 2-year rainfall event within the pipes, keep the HGL below gutter line and bring this drainage system to current City of Houston standard. See exhibit 'G' for the drainage sub area map.

F. Drainage Sub-Area W0014:

After replacing all existing substandard inlets and storm sewer lines in this system, a proposed 2-year design analysis was performed using SWMM. See Appendix 'C' for final 2-year HGL worksheet.

The proposed storm sewers and inlets will contain the 2-year rainfall event within the pipes, keep the HGL below gutter line and bring this drainage system to current City of Houston standard. See exhibits 'H & I' for the drainage sub-area map.

The proposed storm sewer was then subjected to the 100-year rainfall event. When compared to the existing 100-year outflow (peak flow at the outfall 1500 cfs), the proposed 100-year (peak flow at the outfall is 1580 cfs) resulted in an additional peak flow of 80 cfs at the outfall to the Bayou. See Appendix 'E' for the final 100-year HGL worksheet. The mitigation of this impact is further discussed in Section VI Impact Analysis and Mitigation.

VI IMPACT ANALYSIS AND MITIGATION

Storm Sewer improvements proposed in Drainage Sub-Area W0014 resulted in the additional peak runoff of 80 cfs at the outfall to Buffalo Bayou at Kirkwood Drive (See Junction No.2611, Appendix 'D' & 'E'). It is important to note that the increase in peak runoff is due to increased system efficiency resulted in upgrading of the existing storm sewer system to the current City standard rather than increased imperviousness in the drainage area. Along Buffalo Bayou, several storm sewer improvement projects being studied by various consultants for the City of Houston, these projects are in a fully developed neighborhoods and each storm sewer improvement project may cause impact downstream. It may not be possible to mitigate the impact for each project, onsite due to lack of available land for detention.

The most economical and efficient mitigation for impacts caused by storm sewer improvement projects along Buffalo Bayou, is the construction of a regional online detention basin. This basin can be constructed either by widening the banks of the bayou within the bayou right-of way, or by acquiring property along the bayou and constructing an online detention basin which will store 100-year overflow from the bayou. This facility could be used for park and recreational purposes in non-overflow periods.

The impact caused by the proposed improvements discussed in Section V above need to be mitigated by providing a detention basin with a volume of 34.2 acre-feet. This basin will detain the peak runoff difference between existing condition and proposed condition of 80 cfs.

VII PRELIMINARY COST ESTIMATE

Preliminary cost for the above proposed improvements that accommodate the current City of Houston 2-Year storm run-off for all six drainage sub-areas are \$8,474,325.00. A detailed cost estimate for the individual drainage sub-areas is provided in Tables 1 through 7. The preliminary cost estimate to construct a detention basin to mitigate the impact is \$ 439,625.00. A detailed cost estimate for the detention basin is provided in Table 8.

VIII CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis outlined in this report, the conclusions and recommendations are as follows:

A. CONCLUSIONS

1. Some of the storm sewer system in this project does not meet current City of Houston design criteria. Generally inlets and storm sewer pipes are undersized.
2. Street ponding can be expected in various areas in this project during the 2-year rainfall event. This is not acceptable, based on the current City standard.
3. The main trunk storm sewer system along Kirkwood is adequate per our study. The upstream branches of the storm sewer system are inadequate.
4. In several areas we observed that the pavement has settled and created low spots where temporary ponding occurs. (See Appendix 'A', photo Nos. 18, 19, 20, 23 and 25.

B. RECOMMENDATIONS

1. In order to bring the drainage systems in these drainage sub-areas to standard, we recommend that the City of Houston consider removal of all type 'B' inlets and replace them with type 'B-B' inlets, and replace all inlet leads to 24-inch pipes.
2. We recommend that the City of Houston consider removal and replacement of all storm sewer trunk lines as shown in Exhibits 'C' through 'I', and itemized on Table 2 through Table 7.
3. We recommend that the City consider a regional detention pond in consultation with the Army Corp of Engineers and Harris County Flood Control District to mitigate impacts caused by storm sewer project improvements along Buffalo Bayou.